

# Emerging Technologies in the Construction Industry

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## ABSTRACT

In spite being a \$12 trillion giant, the architecture, engineering, and construction (AEC) industry has historically been slow to embrace new technologies, largely due to a lack of understanding and implementation support. Today, technology has been a driving force in the construction industry. The industry has continually evolved, seeking new methods to enhance efficiency. It is experiencing a wave of emerging technologies that promise to transform the way things are built. These technologies include artificial intelligence, machine language, robotics, Building Information Modelling (BIM), cloud-based project management, virtual reality, 3D printing, Internet of things, and blockchain. This paper addresses the implementation of these technologies in the construction industry.

**KEYWORDS:** *technology, emerging technologies, construction industry*

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## INTRODUCTION

Technology changes our lives constantly. Traditionally, construction managers relied on manual methods and paper-based documentation to perform key duties such as overseeing labor, costs, and schedules. But over the decades, technology like power tools and heavy-duty equipment emerged, improving productivity and safety. Technology in construction has truly come a long way for an industry that has the unfortunate reputation of being “slow to adopt.” Modern construction managers now find themselves at the intersection of technology and construction. Larger construction enterprises have been experimenting with the use of new technologies for a while. There has never been a better time for technology adoption in construction. Figure 1 shows a building under construction [1].

The field of construction has expanded at an astounding pace in the past decade. The digitization of the construction industry is perhaps most clearly seen in the proliferation of cloud-based data analytics and project management platforms tailored to the sector’s needs. New technologies have continually

revolutionized the way construction projects are managed and delivered. Technology has enabled construction workers and managers to access real-time data, allowing them to make informed decisions on the spot. Figure 2 shows some construction workers [2].

## WHAT ARE EMERGING TECHNOLOGIES?

Technology may be regarded as a collection of systems designed to perform some function. It can help alleviate some of the challenges facing business today. Emerging technology is a term generally used to describe new technology. The term often refers to technologies currently developing or expected to be available within the next five to ten years. Any imminent, but not fully realized, technological innovations will have some impact on the status quo.

Emerging technologies are shaping our societies. They continue to affect the way we live, work, and interact with one another. Emerging technology (ET) lacks a consensus on what classifies them as “emergent.” It is a relative term because one may see a technology as emerging and others may not see it

the same way. It is a term that is often used to describe a new technology. A technology is still emerging if it is not yet a “must-have” [3]. An emerging technology is the one that holds the promise of creating a new economic engine and is trans-industrial. ET is used in different areas such as media, healthcare, business, science, education, or defense.

The characteristics of emerging technologies include the following [4]:

- *Novelty*: Emerging technologies are typically new or novel, meaning they have yet to be widely adopted or used. They often represent a significant departure from existing technologies or processes.
- *Potential for Disruption*: Emerging technologies have the potential to disrupt existing markets, industries, or ways of doing things. They may also displace existing businesses or industries.
- *Uncertainty*: Because emerging technologies are still in the early stages of development, there is often a high uncertainty surrounding their future potential and impact. It can be challenging to predict how they will evolve.
- *Rapid Change*: Emerging technologies often evolve rapidly, with new developments and innovations emerging frequently. It can make keeping up with the latest trends and advancements challenging.
- *Interdisciplinary*: Emerging technologies often involve multiple disciplines or fields of study, such as computer science, engineering, and biology. They may require collaboration across different fields and industries to develop their potential fully.

Emerging technologies are worth investigating. They are responsible for developing new products or devices. As emerging technologies continue to evolve, engineering is poised for a transformative future. Emerging technologies have driven innovation and progress in today's rapidly evolving digital landscape. The collective impact of emerging technologies such as artificial intelligence, machine learning, big data, and the Internet of things is undeniably transformative.

## EMERGING TECHNOLOGIES IN CONSTRUCTION

The emergence of artificial intelligence, machine language, robotics, Building Information Modelling (BIM), cloud-based project management, virtual reality, and blockchain has transformed construction industry, allowing for more precise planning, increased productivity, and better resource

management. We now consider the following emerging technologies in the construction industry [5]:

1. *Artificial Intelligence*: AI has provided benefits to construction projects through increased safety, improving workflows, and getting jobs done faster and better. It is employed for project scheduling and resource management, significantly improving efficiency. Machine Learning is a method of data analysis based on the idea that systems can learn from data, identify patterns and make decisions with minimal human intervention. Machine learning is helping construction pros optimize their workflows and aid decision-making. AI is increasingly shaping the future of the construction industry by enhancing safety, streamlining workflows, and accelerating project completion. Construction Management Association of America (CMAA) proclaimed AI has the potential to increase industry profits by 71% by 2035. Generative AI is transforming the construction industry by streamlining design processes and enabling smarter, data-driven decision-making. IT can streamline processes, automate repetitive tasks, and optimize resource allocation. Architects and engineers leverage this technology to produce multiple design iterations, optimize material usage, and simulate environmental impacts, delivering more efficient and sustainable results.
2. *Robotic Automation*: The adoption of robotics and automation in the construction industry is transforming how construction companies execute complex construction projects. Robotics is transforming construction sites, with robots being used for tasks such as bricklaying, material handling, demolition, and even 3D printing of entire structures. Robotics in construction is revolutionizing the way tasks like bricklaying, demolition, and excavation are conducted. These robotic tools not only reduce the necessity for manual labor, thus decreasing potential injuries and worker fatigue but also boost efficiency and enhance safety on-site. By automating routine and repetitive tasks, the construction industry can mitigate the effects of labor shortages. The integration of robotics in the construction industry faces challenges such as high initial costs and a skills gap within the workforce. Robotics and other automated technologies also enhance productivity, allowing skilled workers to focus on more complex aspects of construction. The continued adoption of robotics in construction is another significant development that will shape

the industry's future. Figure 3 shows a typical workflow automation [6].

3. *Drones*: Many construction sites are heavily relying on the use of drones, also known as, unmanned aerial vehicles (UAV). Drones are the most widely used emerging construction technology. They have become a cornerstone technology in the construction industry, offering significant advantages for surveying and inspecting sites. They give contractors an overhead and close-up view with images and videoS, and collecting data with other technologies like thermal sensors and GPS tools. They are reshaping construction technology by providing advanced tools for site management, safety, and data collection. They revolutionize site surveying by capturing aerial images and generating detailed maps. Not only do they offer a bird's-eye view for project monitoring and surveying, but construction managers can use drones to conduct site inspections, monitor progress, and capture high-resolution images for detailed analysis. One of the key benefits of drones is their ability to access and inspect hard-to-reach areas such as bridges and the exteriors of tall buildings safely. Utilizing drones and sensors for continuous surveillance improves response times to potential safety hazards, ensuring constant oversight. Drones not only enhance the safety of inspections by keeping workers off dangerous heights but also bring efficiency to data collection across expansive or difficult terrain. Figure 4 illustrates a construction drone [7].
4. *Internet of Things (IoT)*: The Internet of Things is a larger concept that prioritizes interconnected systems and has brought about a new era of connectivity on construction sites. Sensors and smart devices are embedded in construction equipment, tools, and even building materials, providing real-time data on performance, usage, and safety. In the construction industry, the IoT can allow construction machinery, equipment, materials, structures, and more to talk to a central data platform. We must not forget about the impact of IoT on the end-user experience. Imagine a world where the buildings we construct are not just functional, but also intelligent, creating a truly personalized living or working environment.
5. *3D Printing*: 3D printing in the construction industry has seen remarkable advancements, particularly in 3D concrete printing. As a construction technology, it has the potential to change material sourcing. Materials such as concrete and composite materials can be used in these printers, enhancing design flexibility and the structural integrity of buildings. Although 3D printing currently faces challenges in mass production due to the high cost of large-scale printers, it offers substantial benefits, including faster construction timelines, cost savings, and the ability to create complex, customized architectural designs. 3D printed construction materials are often cost effective due to the decreased need for labor and shipping costs associated with traditional construction methods. 3D printing makes it possible to print materials right on site, reducing waste and further saving on transportation and storage costs. Figure 5 shows 3D printing in construction [8].
6. *Blockchain*: Blockchain technology is rapidly becoming a transformative force in the AEC industry. Blockchain serves as a digital ledger, composed of linked data "blocks" that record every transaction and completed milestone in a project. This setup not only enhances cost management and procurement strategies but also introduces a high level of accuracy and security. As we look ahead, the decentralized nature of blockchain makes it a robust, adaptable tool for projects of any size. The Architecture, Engineering, and Construction (AEC) industry is poised to enhance cost management and procurement strategies through the adoption of blockchain technology. Figure 6 depicts a construction worker using blockchain [8].
7. *Wearables*: Wearables are a construction technology that are not only making a positive impact on safety, but also productivity. They are now being built into all kinds of construction apparel such as safety vests, gloves, hard hats, and work boots. Beyond safety, wearables can also be embedded with other technology such as cameras and GPS modules. Wearables in the construction industry go beyond traditional personal protective equipment like hard hats, gloves, and work boots, enhancing safety and productivity significantly. Smart clothing, or e-textiles, further extends the capabilities of wearables in construction.
8. *Virtual Reality*: Extended Reality (XR) serves as the encompassing term for a spectrum of captivating and interactive technologies, including Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). Virtual and augmented reality remain transformative technologies in the construction industry, offering



advanced visualizations and enhancing collaboration. VR/AR enhances teamwork by enabling real-time communication and collaboration across dispersed teams. Virtual reality (VR) is transforming traditional construction methods, allowing for more accurate spatial planning and project execution, VR technology is used in safety training programs to simulate realistic scenarios. This allows workers to gain experience and practice handling dangerous situations in a controlled, risk-free environment. VR technology allows stakeholders to visualize and interact with project designs before construction begins, offering a powerful tool for enhancing understanding and communication between clients, designers, and builders. This technology plays a pivotal role in revolutionizing Architectural, Engineering, and Construction (AEC) workflows. Architects and construction workers now have access to virtual reality technology that enables them to accurately test out designs, plan projects and create virtual 3D models of their build specifications. By implementing the virtual reality in the process, the process of visualizing of 2-D drawings or mock-up construction is eliminated. Figure 7 shows the use of VR in construction planning [7].

9. *Cybersecurity*: This has become a critical concern as reliance on digital tools increases. Ensuring the security of sensitive data is paramount as more aspects of construction operations go digital. In an industry where sensitive data and critical infrastructure collide, the need for robust security measures is paramount. The construction industry is stepping up its game, investing in advanced encryption, threat detection, and incident response protocols.
10. *Building Information Modelling (BIM)*: Another hot construction technology trend is BIM which promises to bring more accuracy to the building process. A construction team comprises many members, each one responsible for several aspects of the building process that will eventually bind together upon the completion of a project. BIM pairs architects with engineers and construction professionals. It is an intelligent process that allows architects, contractors, and engineers to collaborate on the construction, design, and operation of a building. It has the ability to depict project development in an open and highly collaborative environment. The use of BIM provides space for better collaboration because each person and expertise area can add their piece

to the same model, instead of broken out onto multiple versions of a 2D paper drawing.

BIM streamlines information sharing, adding value to the data and enabling its reuse. As a result, teams can work more effectively and avoid errors or redundancies. It also helps with problem solving in the design and planning stages of a project, by automating clash detection and providing a more complete picture of the project. While BIM is primarily used for buildings, a similar technology, bridge information modeling, provides the same functionality for bridge builders. For example, BIM was extensively used in the creation of the Shanghai Tower, an internationally recognized architectural project, shown in Figure 8 [8].

11. *Cloud Technology*: Cloud operating systems have already been in use in many industries. Today, with mobile devices leveraging cloud technology (anywhere, anytime), you can look forward to storing massive amounts of information, and sharing it instantly. Cloud solutions can not only facilitate storing large amounts of data but also in making it accessible for project managers, keeping it secure in a remote location. With construction projects featured with high fragmentation, and different teams having little or no synchronization, you can expect cloud-based collaboration solutions, addressing the gap efficiently.

## BENEFITS

Technological advancements are helping to overcome traditional challenges such as project delays and costs, labor shortages, and safety concerns. Emerging technologies are helping construction companies eliminate long-standing inefficiencies and low productivity. The adoption of emerging technologies is significantly transforming the construction industry, enhancing efficiency, productivity, and safety throughout the construction process. Other benefits in the implementation of the emerging technologies include the following [9]:

- *Real-Time Data and Analytics*: Technology can provide real-time data on workforce productivity and project progress. Construction companies can use this data to identify areas for improvement, optimize labor allocation, and make data-driven decisions about staffing needs.
- *Increased Safety*: It goes without saying that safety is paramount in construction and it always will be. Construction technology has evolved significantly over time, driven by increasing demands for efficiency and safety. It can not only

mitigate risks but also foster a culture of safety that spreads through all levels of a construction project. Being able to constantly monitor worker safety will alleviate a lot of pressure operators face in the construction industry, drastically reducing both the fatality and injury rates.

- *Automation:* Technology can streamline and automate payroll processes, reducing errors and saving time. For example, cloud-based payroll systems can automate tasks like calculating overtime and deductions, ensuring workers are paid accurately and on time.
- *Increased Productivity:* Cloud-based construction management software automates various routine tasks, leading to substantial time savings and thus increased productivity.
- *Attracting New Talent:* As construction becomes more reliant on technology, the demand for workers with digital skills will increase. The integration of advanced technologies such as 3D printing, AI, and robotics into construction roles makes the field more appealing to a new generation of workers. These technologies offer a modern and engaging work environment, attracting individuals interested in tech-driven careers.
- *Efficiency:* Modern project management software has become a cornerstone of efficient operations for construction companies. Emerging technologies AI and 3D printing are revolutionizing the construction industry. These technologies automate tedious tasks, significantly increasing efficiency, reducing the need for a large workforce, and allowing technicians to concentrate on specialized tasks.
- *Self-Healing Concrete:* Self-healing concrete is a miraculous material that shows promise for bridge- and roadwork. This type of concrete is created by adding special fibers or capsules containing adhesive liquids into the concrete mix. It has reparative properties and can seal cracks autogenously or autonomously.
- *Enhanced Collaboration:* These platforms facilitate improved collaboration among teams by providing a centralized location for all project-related documents, drawings, and schedules.
- *Costs:* AI can also be used to predict costs and identify areas where money can be saved, which is great for budget management. For example, AI-enabled systems can help assess material tracking and project build size.

## CHALLENGES

New and emerging technologies are presenting the construction industry with a broad range of transformative opportunities for enhanced business growth, operational efficiencies, and much more. However, with these new opportunities come new challenges and risks. Challenges in the implementation of the emerging technologies include the following [10]:

- *Resistance to Change:* The construction industry is fraught with resistance to change. This has resulted in productivity growth that has lagged other sectors. Stakeholders in the construction industry have been reluctant to follow the digital world in adopting innovations. The attitude obscures their understanding of the technology. As a result, continuous demand for hardware and software upgrades has been a significant challenge for implementing several emerging technologies. However, modern-day professionals are tech-savvier, and more open to the new technologies the market has to offer.
- *Privacy:* As the digital landscape evolves, construction companies must navigate a complex web of regulations and consumer expectations. Imagine a world where your clients can trust that their personal information is handled with the utmost care, from the initial design consultation to the final building inspection.
- *Collaboration:* The construction technology wave is finally here and collaboration tools are just the tip of the iceberg. Construction collaboration and remote monitoring tools moved to the forefront as the need for such tools had never been more obvious. In today's fast-paced world, simply adding more people to a project team is not always enough to ensure efficient collaboration.
- *Sustainability:* As the world grapples with the pressing issues of climate change and environmental stewardship, the construction industry has a unique opportunity to lead the charge. Imagine a construction site where the materials we use are not just strong and durable, but also eco-friendly and recyclable. Picture a construction site where the energy we consume is not just clean, but also cost-effective, ensuring that sustainability and profitability can coexist in perfect harmony. Although the path to a sustainable future may seem daunting, but the construction industry is embracing the challenge with open arms.
- *Labor Shortages:* These have increased demand for labor and time-saving technologies, and recent

advances have given rise to a new generation of more efficient, flexible, and adaptive construction technologies.

- **Costs:** It is widely noticed that the adoption of these innovations can minimize costs related to labor and injuries. At the same time, these technologies are considered expensive and the cost includes the technology systems, software, skilled engineers, and training. Successfully adopting the new technologies will require that companies evaluate their costs, benefits and risks and update construction practices as needed. For example, 3D printers are expensive, and the purchase price does not include materials or maintenance. Quality in 3D printing could become a costly mess if not constantly monitored. Companies who use the new technology will have to repeatedly pay the high price of a software system applying for security patches to keep their software efficient.
- **Interoperability:** When it comes to interoperability between BIM systems and augmented reality (AR) and virtual reality (VR) models, it is difficult to automatically update BIM models and construction schedules from AR and VR systems. Thus, the lack of integration between data standards makes it challenging to integrate BIM data photogrammetry and VR platforms.
- **Cloud Access:** Cloud access is basically over the Internet with technologies like cloud computing and the Internet of Things (IoT). Hence, to maximise the benefits of cloud solutions on the construction site, Internet connectivity must be available all the time. Poor network connectivity is among the challenges to cloud adoption by the construction industry.

## CONCLUSION

The belief that the construction industry lags in adopting modern technology no longer holds true. Organizations like the American Institute of Constructors (AIC) recognize that to succeed in today's fast-paced environment, it is important to understand how technology has transformed the responsibilities of construction managers. The emerging technologies are bringing greater efficiency, productivity, and safety to the construction process. By leveraging emerging technologies, construction companies can save time and money, reduce waste, and improve overall project results.

The construction industry is experiencing a wave of emerging technologies that promise to transform the way things are built. Although some of these

emerging technologies are still in their infancy, they offer immense potential for the future of construction. In the future of construction, technology reigns supreme and innovation knows no bounds. More information about emerging technologies in the construction industry can be found in the books [11-13].

## REFERENCES

- [1] "The seven coolest construction technologies for 2023," January 2023, <https://www.viewpoint.com/blog/seven-coolest-construction-technology-2023>
- [2] "5 Emerging technologies in the construction industry," <https://www.worldconstructiontoday.com/news/5-emerging-technologies-in-the-construction-industry/>
- [3] M. Halaweh, "Emerging technology: What is it?" *Journal of Technology Management & Innovation*, vol. 8, no. 3, 2013, pp. 108-115.
- [4] N. Duggal, "Top 18 new technology trends for 2023," July 2023, <https://www.simplilearn.com/top-technology-trends-and-jobs-article>
- [5] C. Soto, "Construction technology: 16 building technologies driving the future," May 2024, <https://openasset.com/blog/construction-technology/>
- [6] S. Ahmed, "3 Game-changing construction technology trends to keep an eye on," July 2021, [https://www.ontraccr.com/post/3-game-changing-construction-technology-trends-to-keep-an-eye-on?utm\\_term=&utm\\_campaign=Workflow+Templates&utm\\_source=adwords&utm\\_medium=ppc&hsa\\_acc=2152464631&hsa\\_cam=21440234582&hsa\\_grp=&hsa\\_ad=&hsa\\_src=x&hsa\\_tgt=&hsa\\_kw=&hsa\\_mt=&hsa\\_net=adwords&hsa\\_ver=3&gad\\_source=1&gclid=CjwKCAiAgoq7BhBxEiwAVcWOLK1djOkIHjw3HCip9TfWc5qfdpd4kS2PZ4vsHsm116KWMAFaISOokxoCwo0QAvD\\_BwE](https://www.ontraccr.com/post/3-game-changing-construction-technology-trends-to-keep-an-eye-on?utm_term=&utm_campaign=Workflow+Templates&utm_source=adwords&utm_medium=ppc&hsa_acc=2152464631&hsa_cam=21440234582&hsa_grp=&hsa_ad=&hsa_src=x&hsa_tgt=&hsa_kw=&hsa_mt=&hsa_net=adwords&hsa_ver=3&gad_source=1&gclid=CjwKCAiAgoq7BhBxEiwAVcWOLK1djOkIHjw3HCip9TfWc5qfdpd4kS2PZ4vsHsm116KWMAFaISOokxoCwo0QAvD_BwE)
- [7] "Modern construction technologies transforming the industry," August 2023, <https://www.planradar.com/sa-en/modern-construction-technologies/>
- [8] J. Goyal, "10 Emerging technologies transforming the construction industry in 2024," March 18, 2023, <https://www.novatr.com/blog/emerging-construction-technology-trends>



- [9] S. Coronado, "How emerging construction industry technology is shaping the future," July 2024, <https://www.ebacon.com/business-tips/how-emerging-construction-industry-technology-is-shaping-the-future/#:~:text=Real%2DTime%20Data%20and%20Analytics,driven%20decisions%20about%20staffing%20needs.>
- [10] E. Kissi, C. Aigbavboa, and E. Kuoribo, "Emerging technologies in the construction industry: Challenges and strategies in Ghana," January 2022, [https://www.researchgate.net/profile/Ewald-Kuoribo/publication/358357275\\_Emerging\\_technologies\\_in\\_the\\_construction\\_industry\\_challenges\\_and\\_strategies\\_in\\_Ghana\\_Challenges\\_and\\_strategies\\_in\\_Ghana/links/6429465e92cfd54f844a0596/Emerging-technologies-in-the-construction-industry-challenges-and-strategies-in-Ghana-Challenges-and-strategies-in-Ghana.pdf](https://www.researchgate.net/profile/Ewald-Kuoribo/publication/358357275_Emerging_technologies_in_the_construction_industry_challenges_and_strategies_in_Ghana_Challenges_and_strategies_in_Ghana/links/6429465e92cfd54f844a0596/Emerging-technologies-in-the-construction-industry-challenges-and-strategies-in-Ghana-Challenges-and-strategies-in-Ghana.pdf)
- [11] J. B. de Lartigue, *How to Surf the Waves of Change in the Construction Industry?: Advanced Construction Management: BIM Implementation Methodology, Technologies, and Leadership to Deliver Sustainable Buildings*. Kindle Edition, 2024.
- [12] J. J. Hannon, *Emerging Technologies for Construction Delivery*. Transportation Research Board, 2007.
- [13] U. Vanka, *The Future Is BIG: How Emerging Technologies are Transforming Industry and Societies*. Business Expert Press, 2023.



**Figure 1 A building under construction [1].**



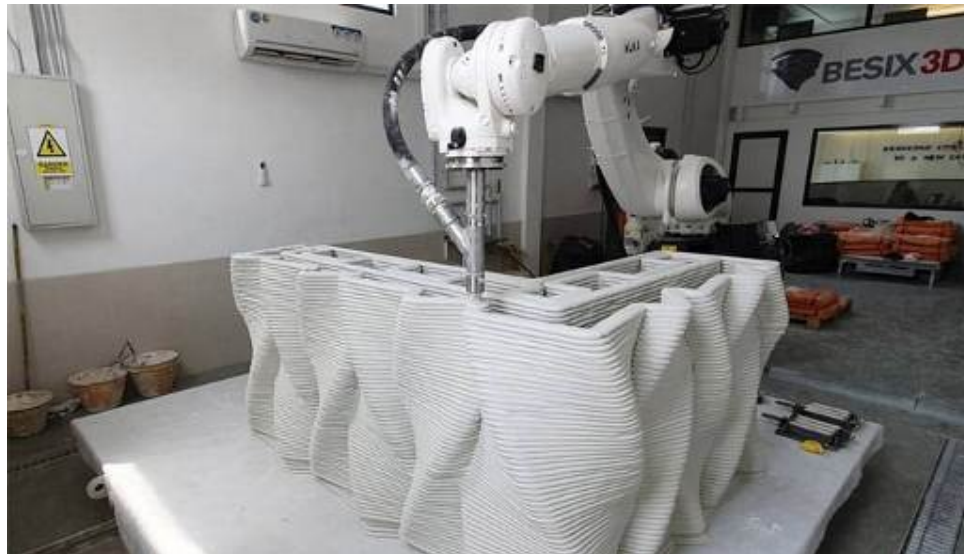
**Figure 2 Some construction workers [2].**



**Figure 3 A typical workflow automation [6].**



**Figure 4 A construction drone [7].**



**Figure 5 3D printing in construction [8].**





**Figure 6 A construction worker using blockchain [8].**



**Figure 7 Use of VR in construction planning [7].**



**Figure 8 BIM was extensively used in the creation of the Shanghai Tower [8].**